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RESEARCH PAPER

Development and performance evaluation of pedal operated maize sheller

■ **S.B. PATIL**, A.D. CHENDAKE, M.A. PATIL, S.G. PAWAR, R.V. SALUNKHE **AND** S.S. BURKUL

ABSTRACT

A pedal operated maize Sheller was designed, developed and built by using locally available material with overall dimensions of 1270×760×1150 mm. The machine could be operated continuously for a comparatively long time with high shelling rate without causing damage to kernels. Four shelling units were provided for shelling of maize cobs and operated with the chain and sprocket arrangement. The results revealed that the machine was easy to operate with an average kernel shelling rate of 110 kg/hr when operated by two persons with no any kernel damage. Shelling efficiency was 98 per cent with collection efficiency of 94 per cent and average rate throughout was 150 kg/hr.

KEY WORDS : Shelling efficiency, Collection efficiency, Shelling rate, Moisture content

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INTRODUCTION

Shelling is a necessary process subsequent to harvesting because the maize kernels when harvested are firmly attached to the hard cob. Most of the low acreage maize growers encounter several difficulties in shelling as it involves relatively high labour expenditures and human energy. The energy consumption for only shelling of maize cob was 16.49 per cent of total operational energy used in rainfed cultivation of maize crop in India (De, 2005). Singh (2010) reported that the farm women could dehusk 59 kg un-dehusked cobs/h. The farm women have to use their hands for nailing (1-2 times), tearing (2-3 times) and plaming (1-2 times) in order to dehusk a cob taking about 8-10 s. In 1980 s some efforts were made to develop pedal operated maize dehusker-sheller in octagonal cylinder using rubber strips and rasp bars operated by two men workers (Ali *et al.*, 1986). Shelling has previously been accomplished either by rubbing the maize cobs against one another by hand or by direct removal of kernels with low shelling rate. Another shelling technique for maize shelling is hand beating technique in which sacks stuffed with maize are beaten with a wooden flail (Anonymous, 2000 and 2008; Bharati, 1998 and Nkakini, 2007). This method causes damage to the kernels. Thus, the quest for a satisfactory cheap effective means of detaching the kernels from the cob is important to the small and even medium size farmers in the country. Now a day, few motorized, tractor/ power tiller operated machines have come into the market but the prices of these machines are not affordable to the peasant farmers. Also some designs of hand operated maize shellers have been developed but they shell only one cob at a time and have limitations to use it continuously for a longer period of time. Therefore, it was the aim of this investigation to develop and built a maize sheller using locally available material so that the machine will be operated continuously for a longer period of time with high rate of shelling without causing damage to the kernels and evaluate the performance of developed machine for shelling rate, shelling efficiency, kernel damage, kernel collection efficiency and the rate of throughput.

EXPERIMENTAL PROCEDURE

Development of machine :

The pedal operated maize shelling machine (1270×760×1150 mm) consist of frame, power transmission system, shelling unit, extension to shelling unit, kernel collection tray, sitting arrangement for operator, safety guards and bearings (Fig. A). The main frame was made of MS angles and C channels, it was made heavy to have better balance and stability during pedaling. The simple bicycle chain drive mechanism was used for transmission of power. The bigger sprocket connected with the two pedals acted as driver and drives two equal size smaller sprockets were mounted on the 20 mm diameter shafts of the shelling unit. The pedaling can be easily done by the operator by sitting on the well cushioned seat of size 305×350 mm and the pedaling power gets transmitted to the shelling unit through the chain. The shelling unit actually shells out the kernels from the maize cob when rotated by pedal. The shelling was made up of MS round pipe of length 75 mm and diameter of 65 mm. The pipe consists of four kernels detaching strips welded along the length of pipe at equal distance (90^0 degree apart from one another) from inside of the pipe. Eight holes of 18 mm diameter were drilled on the surface of shelling unit to facilitate easy dropping of detached kernels from shelling unit preventing chocking of shelling unit with shelled kernels of maize.

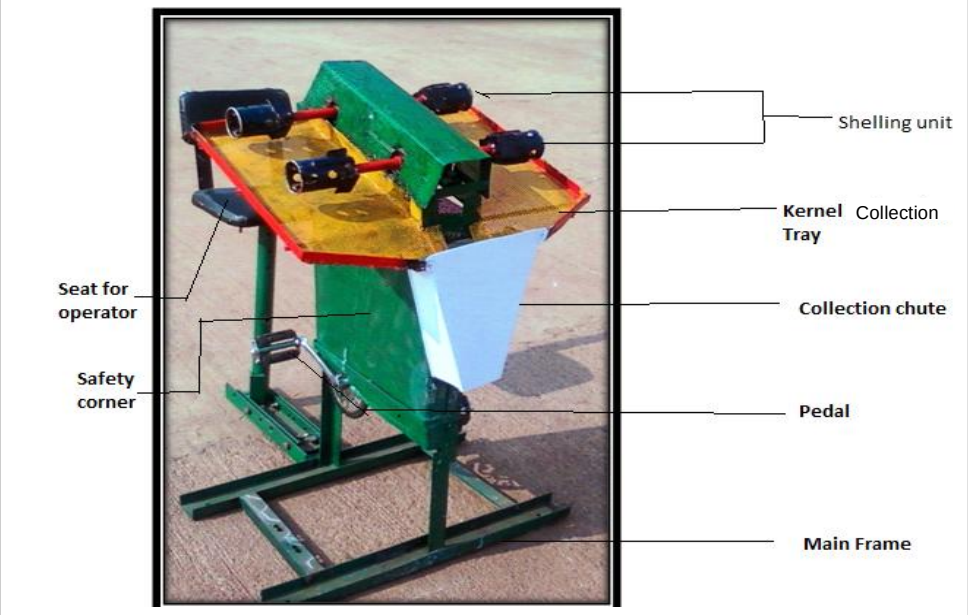

Fig. A : View of maize sheller machine

In order to shell the longer size cobs the length of shelling unit was extended by welding a C channel piece of 35 mm length to the shelling unit. The extension accommodates any length of the cob and help for increasing shelling efficiency.

Two perforated MS foil trays (260×460 mm) were fixed 30 mm below the rotating maize shelling units on either sides of the frame which acted as collection trays. A 25 mm height MS strip was welded on the outer edges of kernel collection tray as kernel arrester. The collection tray was given a slope of 20^0 to facilitate easy rolling of kernels falling in a tray after being shelled. The lower ends were connected to collection chute to facilitate the easy collection of shelled kernels in container or bag.

The safety covers were provided on the either sides of chain and sprocket drive and on the top of the machines to prevent accident due to interference of body parts as well as cloths in the chain and sprockets.

Evaluation of machine :

The operators were given the tips, information and working of the machine for 20 min before starting the actual trials. In each trial machine was operated for 30 min to shell the maize cobs. Three trials of the machine were conducted on the maize cobs with moisture content of 12 per cent. The weight of detached kernels collected in the tray and from the collection unit, spread kernels, damaged kernels and completely shelled cob was recorded after each trial to determine shelling rate, shelling efficiency, collection efficiency, average rate throughout and kernel damage percentage. The definitions and calculations of these parameters are as under.

Shelling rate :

The weight of the maize kernels (whole + broken) detached from the cobs in unit time was taken at shelling rate. It was calculated as :

$$\text{Shelling rate} = \frac{Ww + Wb}{t} \times 100 \frac{Ws}{t} \times 100$$

where,

$W_s = W_w + W_b$ =weight of shelled (detached) maize kernels, g.

W_w = Weight of whole kernels detached from the cobs, g.

W_b = Weight of broken kernels deatched from the cobs, g

t = Time, sec.

Percentage of unshelled grains :

it was calculated as :

$$\text{Percentage of cracked and broken grains} = \frac{\text{Weight of cracked and broken grains from specified grain outlet, kg}}{\text{Total weight of grain received at all grain outlets, kg}} \times 100$$

Collection efficiency :

It is the percentage of kernels collected (in tray and in bag or container) from the total kernels shelled (detached) from the cobs, it was calculated as :

$$\text{Collection efficacy} = \frac{Wc}{Ws} \times 100 = \frac{Wst + Wsb}{Ws} \times 100$$

where,

W_c = weight of kernels collected at machine, gm

W_{st} = weight of shelled kernels collected in collection tray, g.

W_{sb} = weight of shelled kernels collected in bag or container, g.

Rate of throughput :

The weight of the maize kernels attempted by the machine in unit time was taken as rate of throughput and it was calculated as :

$$\text{Rate of throughtput, (kg/hr)} = \frac{W}{t} = \frac{Ws + Wu + Wsc}{t}$$

where,

W = Total weight of cobs with kernels attached, g.

W_{sc} = weight of completely shelled cob, g.

Kernel damage percentage :

The ratio of weight of damage kernels to total weight of kernel was taken as Kernel damage percentage :

$$\text{Kernel damage percentage} = \frac{Wb}{Ws} \times 100$$

Working of machine :

Before the start of shelling process the machine was set up at place where sufficient space was available. Two big size buckets filled with cobs were placed on either sides of machine to facilitate easy access to both the workers to pick up.

The driver of the machine started pedaling by sitting on the seat provided and the driver started pedaling the four shelling units started rotating. The driver and other worker were picking up the cobs from the buckets placed on either side and put them into the rotating shelling units by their both the hands. The rotating motion of the shelling unit shell out the kernels and detached kernels fall on the kernel collection trays from where they got collected through collection chute in the bag or container placed below the collection chute. The Fig. B shows the set up in working condition.

Fig. B : Set up in working condition

EXPERIMENTAL FINDINGS AND ANALYSIS

The results obtained from the present investigation are summarized below :

Shelling rate:

The pedal operated maize sheller when operated with two persons at a time, the kernel shelling rate varies from 100 kg/hr to 120 kg/hr with different pair of operator with an average shelling rate of 110 kg/hr (Table 2). Whereas, in case of hand operated maize sheller the kernel shelling rate varies from 20 kg/hr per person to 25 kg/hr per person with an average of 23 kg/hr per person (Table 1).

The higher shelling rate per person (2.39 times more) than hand operated maize sheller in case of pedal operated maize shelling machine was mainly due to less effort requirement to operate the machine by legs which increased the speed of operation of machine and the shelling by both hands was possible.

Table 1 : Performance of hand operated maize sheller

Time (min)	Wt. of unshelled cob, gm	Wt. of shelled grain, gm	Wt. of unshelled grain and cob, gm	Wt. of completely shelled cob, gm	Shelling efficiency, %	Shelling rate, (kg/hr)	Throughput capacity, (kg/hr)
30	12540	10462	2078	2078	100	20.93	25.08
30	14536	10472	2760	2720	99.73	23.56	29.07
30	12305	10575	2190	2160	99.74	20.36	24.79

Table 2 : Performance of pedal operated Maize shelling machine

Pair of operator	Time (min)	Total wt. of shelled kernels in			Wt. of unshelled kernels, gm	Wt. of shelled kernels, gm	Wt. of shelled cobs, gm	Wt. of unshelled cobs, gm	Collection efficiency %	Shelling efficiency (kg/hr)	Shelling rate (kg/hr)	Throughput capacity (kg/h)
	30	32000	24320	3600	1080	59920	13200	74200	93.99	98.55	119.84	148.40
P_1	30	35100	21780	3120	840	60000	17520	78360	94.80	98.92	120.00	156.72
	30	32160	23100	3080	1020	58340	16140	75500	94.72	98.65	116.68	151.00
	30	45660	11550	3060	1020	60270	16320	77610	94.92	98.68	120.54	155.22
P_2	30	41210	12020	3200	960	56430	16770	74160	94.33	98.70	112.86	148.32
	30	36230	13520	3040	870	52790	17670	71330	94.24	98.78	105.58	142.66
	30	39230	12130	3740.	880	55100	14920	70900	93.33	98.76	110.20	141.80
P_3	30	40100	10716	3500	760	54316	15100	70176	93.56	98.92	108.64	140.35
	30	39200	9680	2860	920	51740	17660	70320	94.47	98.65	103.48	140.64

Shelling efficiency :

The shelling efficiency of both pedal operated and hand operated maize sheller was almost same. The shelling efficiency of pedal operated maize sheller varied from 98 per cent to 99 per cent with an average value of 98.5 per cent (Table 2). Whereas, in case of hand operated maize sheller it varied from 98 per cent to 100 per cent with an average of 99 per cent.

Collection efficiency :

The collection of kernels detached by the hand sheller was achieved by placing a plastic tray or basket under the hand sheller and almost 100 per cent of detached kernels were collected.

In case of pedal operated shelling machine perforated trays on either side of machine collected the detached kernels. The collection efficiency of the machine varied from 93 per cent to 95 per cent with an average of 94 per cent (Table 2).

The reason for comparatively less collection efficiency of pedal operated maize sheller was due to comparatively more height of shelling units and operating speed. The shelling of cobs in machine was at the height of 1100 mm from ground and comparatively small catchment area of collection trays per shelling unit caused a little scattering of shelled (detached) kernels on the grounds. The spread kernels can be collected at the end of the shelling operation and do not cause any loss of kernels.

Kernel damage :

Both the hand operated and pedal operated machine detached the kernels from cobs without causing any damage to the kernels.

Rate of throughput :

The throughput rate of pedal operated maize sheller when operated by two persons varied from 140.35 to 156.72 kg/hr with an average of 150 kg/hr (Table 2), whereas, in case of hand operated maize sheller it varies from 24.79 kg/hr to 29.07 kg/hr with an average of 27 kg/hr (Table 1) per person.

Conclusion :

The average rate of throughput of pedal operated maize sheller per person was 150 kg/hr which was 5.5 times more than hand operated maize sheller. The pedal operated maize sheller possesses the ability to shell the dehusked four maize cobs at a time easily and safely and no special skills required to operate it. The average kernel shelling rate, shelling efficiency, collection efficiency and rate of throughput of pedal operated maize sheller with two persons at a time was 110 kg/hr, 98.5 per cent, 94 per cent and 150 kg/hr, respectively as well as there was no damage to the detached kernels by pedal operated maize sheller.

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MEMBERS OF RESEARCH FORUM

AUTHOR FOR CORRESPONDENCE :

S.B. Patil
Dr. D.Y. Patil College of Agricultural Engineering and Technology, Talsande, KOLHAPUR (M.S.) INDIA

CO-OPTED AUTHORS :

A.D. Chendake, Dr. D.Y. Patil College of Agricultural Engineering and Technology, Talsande, KOLHAPUR (M.S.) INDIA
M.A. Patil, Dr. D.Y. Patil College of Agricultural Engineering and Technology, Talsande, KOLHAPUR (M.S.) INDIA
S.G. Pawar, Dr. D.Y. Patil College of Agricultural Engineering and Technology, Talsande, KOLHAPUR (M.S.) INDIA
R.V. Salunkhe, Dr. D.Y. Patil College of Agricultural Engineering and Technology, Talsande, KOLHAPUR (M.S.) INDIA
S.S. Burkul, Dr. D.Y. Patil College of Agricultural Engineering and Technology, Talsande, KOLHAPUR (M.S.) INDIA